C L A I M S

1. A jitter measuring apparatus comprising:

an orthogonal signal generating unit which converts a signal to be measured into two orthogonal signals which are two signals whose phases are orthogonal to one another;

an instantaneous phase calculating unit which calculates an instantaneous phase based on the two orthogonal signals converted by the orthogonal signal generating unit within a range between a lower limit phase value set in advance and an upper limit phase value set in advance;

a differential value detecting unit which detects a differential value of the instantaneous phase calculated by the instantaneous phase calculating unit;

a differential value correcting unit which corrects the differential value of the instantaneous phase, and which outputs a corrected differential value when the differential value of the instantaneous phase detected by the differential value detecting unit is over the range dependent on the lower limit phase value and the upper limit phase value;

an offset component eliminating unit which eliminates an offset component included in the corrected differential value from the corrected differential value output by the differential value correcting unit, and which outputs a differential value from which the

offset component has been eliminated; and

an integration unit which determines a jitter amount of the signal to be measured by integrating the differential value which is output by the offset component eliminating unit, and from which the offset component has been eliminated.

2. The jitter measuring apparatus according to claim 1, wherein

a lower limit and an upper limit of the range dependent on the lower limit phase value and the upper limit phase value are respectively equal to or approximately equal to the lower limit phase value and the upper limit phase value.

3. The jitter measuring apparatus according to claim 1 or 2, wherein

the differential value correcting unit has

a discontinuous point detecting unit which detects the differential value of the instantaneous phase as a discontinuous point of the differential value of the instantaneous phase when the differential value of the instantaneous phase detected by the differential value detecting unit is over the range dependent on the lower limit phase value and the upper limit phase value, and

a continuity insuring unit which insures continuity of the differential value of the instantaneous phase by correcting a discontinuous point of the differential value of the instantaneous phase detected

by the discontinuous point detecting unit with respect to the differential value of the instantaneous phase detected by the differential value detecting unit, and outputting the corrected differential value.

4. The jitter measuring apparatus according to claim 1 or 2, wherein

the differential value correcting unit has

a discontinuous point detecting unit which detects the differential value of the instantaneous phase as a discontinuous point of the differential value of the instantaneous phase when the differential value of the instantaneous phase detected by the differential value detecting unit is over the range dependent on the lower limit phase value and the upper limit phase value, and

a discontinuous point eliminating unit which eliminates the discontinuous point of the differential value of the instantaneous phase detected by the discontinuous point detecting unit with respect to the differential value of the instantaneous phase detected by the differential value detecting unit and outputs the eliminated differential value.

5. The jitter measuring apparatus according to claim 1 or 2, wherein

the differential value correcting unit has

a discontinuous point detecting unit which detects the differential value of the instantaneous phase as a discontinuous point of the differential value of the

instantaneous phase when the differential value of the instantaneous phase detected by the differential value detecting unit is over the range dependent on the lower limit phase value and the upper limit phase value, and

a discontinuous point interpolating unit which substantially insures continuity of the differential value of the instantaneous phase by eliminating the discontinuous point of the differential value of the instantaneous phase detected by the discontinuous point detecting unit with respect to the differential value of the instantaneous phase detected by the differential value detecting unit and interpolating the eliminated portion and outputting the interpolated differential value.

6. The jitter measuring apparatus according to claim 1, wherein

the offset component eliminating unit has

a memory in which a value determined by an operation of $2\pi(fc/fs)$ showing the offset component is stored in advance when a frequency fc of the signal to be measured and a sampling frequency fs for sampling the signal to be measured have been already known, and

a subtraction unit which subtracts the value showing the offset component stored in the memory from the corrected differential value output by the differential value correcting unit.

7. The jitter measuring apparatus according to

claim 1, wherein

the offset component eliminating unit has

a mean value calculating unit which determines a mean value of the corrected differential value output by the differential value correcting unit as an offset component in advance when a frequency fc of the signal to be measured and a sampling frequency fs for sampling the signal to be measured have been unknown, and

a subtraction unit which subtracts the mean value of the corrected differential value serving as the offset component determined by the mean value calculating unit from the corrected differential value output by the differential value correcting unit.

8. The jitter measuring apparatus according to claim 1, wherein,

when a lower limit frequency fj of a jitter component which is an object to be detected is designated, the offset component eliminating unit includes a high-pass filter which has a frequency equal to or approximately equal to the lower limit frequency fj of the jitter component which is the object to be detected as a cutoff frequency for eliminating the offset component from the corrected differential value output by the differential value correcting unit.

9. The jitter measuring apparatus according to claim 1, wherein,

given that a digital signal sequence of the signal

to be measured is x(n), a frequency and an amplitude of the signal to be measured are respectively fc and Ac, a sampling frequency for sampling the signal to be measured is fs, and an initial phase and a jitter of the signal to be measured are respectively θc and φ(n), n=0,1,2, ..., and when I(n), Q(n) serving as the two orthogonal signals are respectively expressed by

$$I(n)=x(n)=Ac\cdot\cos\,[2\pi(fc/fs)n+\theta c+\phi(n)],$$

$$Q(n)=Ac\cdot\sin\,[2\pi(fc/fs)n+\theta c+\phi(n)],$$

and Θ(n) serving as the instantaneous phase is expressed by

$$\begin{aligned}\Theta(n)&=\tan^{-1}\,[Q(n)/I(n)]\\&=2\pi(fc/fs)n+\theta c+\phi(n),\end{aligned}$$

the instantaneous phase calculating unit calculates Θ(n) serving as the instantaneous phase determined by an operation of the $\tan^{-1}$ [Q(n)/I(n)] within a range from −π to π, or −π/2 to π/2 as a range between the lower limit phase value set in advance and the upper limit phase value set in advance.

10. The jitter measuring apparatus according to claim 9, wherein

the differential value detecting unit calculates ΔΘ(n) serving as the differential value of the instantaneous phase calculated by the instantaneous phase calculating unit, by an operation of

$$\begin{aligned}\Delta\Theta(n)&=\Theta(n)-\Theta(n-1)\\&=2\pi(fc/fs)+\phi(n)-\phi(n-1)\end{aligned}$$ (Where, Θ(n−1)=0, and

here, $2\pi(fc/fs)$ is a constant and an offset component).

11. The jitter measuring apparatus according to claim 10, wherein

the differential value correcting unit carries out arithmetic processing of

$$\Delta\theta(n)=\Delta\Theta(n) \qquad (-\pi\leq\Delta\Theta(n)\leq\pi),$$

$$\Delta\theta(n)=\Delta\Theta(n)+2\pi \qquad (-\pi>\Delta\Theta(n)),$$

$$\Delta\theta(n)=\Delta\Theta(n)-2\pi \qquad (\Delta\Theta(n)>\pi)$$

or

$$\Delta\theta(n)=\Delta\Theta(n) \qquad (-\pi/2\leq\Delta\Theta(n)\leq\pi/2),$$

$$\Delta\theta(n)=\Delta\Theta(n)+\pi \qquad (-\pi/2>\Delta\Theta(n)),$$

$$\Delta\theta(n)=\Delta\Theta(n)-\pi \qquad (\Delta\Theta(n)>\pi/2)$$

with respect to $\Delta\Theta(n)$ serving as the differential value of the instantaneous phase in order to calculate $\Delta\theta(n)$ serving as the corrected differential value corrected so as to insure continuity by correcting the discontinuous point of $\Delta\Theta(n)$ serving as the differential value of the instantaneous phase calculated by the instantaneous phase calculating unit.

12. The jitter measuring apparatus according to claim 11, wherein the offset component eliminating unit eliminates the offset component $2\pi(fc/fs)$ from $\Delta\theta(n)$ serving as the corrected differential value corrected so as to insure the continuity by the differential value correcting unit, and outputs

$$\Delta\phi(n)=\phi(n)-\phi(n-1)$$

as $\Delta\phi(n)$ serving as the differential value from which

the offset component has been eliminated to the integration unit.

13. The jitter measuring apparatus according to claim 12, wherein

the integration unit

carries out a following integration

$U(n)=\Sigma\Delta\phi(i)$ (Where, the symbol Σ denotes the sum total of $i=0,1,2,\ ...,\ n$, and here, provided that $U(n)$ is theoretically expanded, it is made to be

$U(n)=[\phi(0)-\phi(-1)]+[\phi(1)-\phi(0)]+[\phi(2)-\phi(1)]+.........+[\phi(n)-\phi(n-1)]$

$=\phi(n)-\phi(n-1)$ with respect to $\Delta\phi(n)$ serving as the differential value which is output by the offset component eliminating unit, and from which the offset component has been eliminated, and

here, given that $\phi(-1)=0$, an integrated result $U(n)$ is to express a jitter component $\phi(n)$ of the signal to be measured, and

outputs the integrated result $U(n)$ as the jitter component $\phi(n)$ of the signal to be measured.

14. A jitter measuring method comprising:

a step of converting a signal to be measured into two orthogonal signals which are two signals whose phases are orthogonal to one another;

a step of calculating an instantaneous phase based on the two orthogonal signals converted by the step of converting into the two orthogonal signals within a

range between a lower limit phase value set in advance and an upper limit phase value set in advance;

a step of detecting a differential value of the instantaneous phase calculated by the step of calculating the instantaneous phase;

a step of correcting the differential value of the instantaneous phase, and outputting a corrected differential value when the differential value of the instantaneous phase detected by the step of detecting the differential value of the instantaneous phase is over the range dependent on the lower limit phase value and the upper limit phase value;

a step of eliminating an offset component included in the corrected differential value from the corrected differential value output by the step of correcting the differential value of the instantaneous phase, and outputting a differential value from which the offset component has been eliminated; and

a step of determining a jitter amount of the signal to be measured by integrating the differential value which is output by the step of eliminating the offset component, and from which the offset component has been eliminated.

15. The jitter measuring method according to claim 14, wherein

a lower limit and an upper limit of the range dependent on the lower limit phase value and the upper

limit phase value are respectively equal to or approximately equal to the lower limit phase value and the upper limit phase value.

16. The jitter measuring method according to claim 14 or 15, wherein

the step of correcting the differential value of the instantaneous phase has

a step of detecting the differential value of the instantaneous phase as a discontinuous point of the differential value of the instantaneous phase when the differential value of the instantaneous phase detected by the step of detecting the differential value of the instantaneous phase is over the range dependent on the lower limit phase value and the upper limit phase value, and

a step of insuring continuity of the differential value of the instantaneous phase by correcting the discontinuous point of the differential value of the instantaneous phase detected by the step of detecting the discontinuous point of the differential value of the instantaneous phase with respect to the differential value of the instantaneous phase detected by the step of detecting the differential value of the instantaneous phase, and outputting the corrected differential value.

17. The jitter measuring method according to claim 14 or 15, wherein

the step of correcting the differential value of the instantaneous phase has

a step of detecting the differential value of the instantaneous phase as a discontinuous point of the differential value of the instantaneous phase when the differential value of the instantaneous phase detected by the step of detecting the differential value of the instantaneous phase is over the range dependent on the lower limit phase value and the upper limit phase value, and

a step of eliminating the discontinuous point of the differential value of the instantaneous phase detected by the step of detecting the discontinuous point of the differential value of the instantaneous phase with respect to the differential value of the instantaneous phase detected by the step of detecting the differential value of the instantaneous phase, and outputting the eliminated differential value.

18. The jitter measuring method according to claim 14 or 15, wherein

the step of correcting the differential value of the instantaneous phase has

a step of detecting the differential value of the instantaneous phase as a discontinuous point of the differential value of the instantaneous phase when the differential value of the instantaneous phase detected by the step of detecting the differential value of the

instantaneous phase is over the range dependent on the lower limit phase value and the upper limit phase value, and

a step of substantially insuring continuity of the differential value of the instantaneous phase by eliminating the discontinuous point of the differential value of the instantaneous phase detected by the step of detecting the discontinuous point of the differential value of the instantaneous phase with respect to the differential value of the instantaneous phase detected by the step of detecting the differential value of the instantaneous phase, and interpolating the eliminated portion, and outputting the interpolated differential value.

19. The jitter measuring method according to claim 14, wherein

the step of eliminating the offset component has

a step of storing a value determined by an operation of $2\pi(fc/fs)$ showing the offset component in a memory in advance when a frequency fc of the signal to be measured and a sampling frequency fs for sampling the signal to be measured have been already known, and

a step of subtracting the value showing the offset component stored in the memory from the corrected differential value output by the step of correcting the differential value of the instantaneous phase.

20. The jitter measuring method according to

claim 14, wherein

the step of eliminating the offset component has

a step of determining a mean value of the corrected differential value output by the step of correcting the differential value of the instantaneous phase as an offset component in advance when a frequency fc of the signal to be measured and a sampling frequency fs for sampling the signal to be measured have been unknown, and

a step of subtracting the mean value of the corrected differential value serving as the offset component determined by the step of determining the mean value of the corrected differential value, from the corrected differential value output by the step of correcting the differential of the instantaneous phase.

21. The jitter measuring method according to claim 14, wherein,

when a lower limit frequency fj of a jitter component which is an object to be detected is designated, the step of eliminating the offset component uses a high-pass filter which has a frequency equal to or approximately equal to the lower limit frequency fj of the jitter component which is the object to be detected as a cutoff frequency for eliminating the offset component from the corrected differential value output by the step of correcting the differential value of the instantaneous phase.

22. The jitter measuring method according to claim 14, wherein,

given that a digital signal sequence of the signal to be measured is $x(n)$, a frequency and an amplitude of the signal to be measured are respectively fc and Ac, a sampling frequency for sampling the signal to be measured is fs, and an initial phase and a jitter of the signal to be measured are respectively θc and $\phi(n)$, n=0,1,2, ..., and when I(n), Q(n) serving as the two orthogonal signals are respectively expressed by

$$I(n)=x(n)=Ac\cdot\cos[2\pi(fc/fs)n+\theta c+\phi(n)],$$

$$Q(n)=Ac\cdot\sin[2\pi(fc/fs)n+\theta c+\phi(n)],$$

and $\Theta(n)$ serving as the instantaneous phase is expressed by

$$\Theta(n)=\tan^{-1}[Q(n)/I(n)]$$
$$=2\pi(fc/fs)n+\theta c+\phi(n),$$

the step of calculating the instantaneous phase calculates $\Theta(n)$ serving as the instantaneous phase determined by an operation of the $\tan^{-1}[Q(n)/I(n)]$ within a range from $-\pi$ to π, or $-\pi/2$ to $\pi/2$ as a range between the lower limit phase value set in advance and the upper limit phase value set in advance.

23. The jitter measuring method according to claim 22, wherein

the step of detecting the differential value of the instantaneous phase calculates $\Delta\Theta(n)$ serving as the differential value of the instantaneous phase

calculated by the step of calculating the instantaneous phase, by an operation of

$$\Delta\Theta(n)=\Theta(n)-\Theta(n-1)$$

$$=2\pi(fc/fs)+\phi(n)-\phi(n-1)$$ (Where, $\Theta(n-1)=0$, and here, $2\pi(fc/fs)$ is a constant and an offset component).

24. The jitter measuring method according to claim 23, wherein

the step of correcting the differential value of the instantaneous phase carries out arithmetic processing of

$$\Delta\theta(n)=\Delta\Theta(n) \qquad (-\pi\leq\Delta\Theta(n)\leq\pi),$$

$$\Delta\theta(n)=\Delta\Theta(n)+2\pi \qquad (-\pi>\Delta\Theta(n)),$$

$$\Delta\theta(n)=\Delta\Theta(n)-2\pi \qquad (\Delta\Theta(n)>\pi)$$

or

$$\Delta\theta(n)=\Delta\Theta(n) \qquad (-\pi/2\leq\Delta\Theta(n)\leq\pi/2),$$

$$\Delta\theta(n)=\Delta\Theta(n)+\pi \qquad (-\pi/2>\Delta\Theta(n)),$$

$$\Delta\theta(n)=\Delta\Theta(n)-\pi \qquad (\Delta\Theta(n)>\pi/2)$$

with respect to $\Delta\Theta(n)$ serving as the differential value of the instantaneous phase in order to calculate $\Delta\theta(n)$ serving as the corrected differential value corrected so as to insure continuity by correcting a discontinuous point of $\Delta\Theta(n)$ serving as the differential value of the instantaneous phase calculated by the step of calculating the instantaneous phase.

25. The jitter measuring method according to claim 24, wherein the step of eliminating the offset component eliminates the offset component $2\pi(fc/fs)$

from $\Delta\theta(n)$ serving as the corrected differential value corrected so as to insure the continuity by the step of correcting the differential value, and outputs

$\Delta\phi(n)=\phi(n)-\phi(n-1)$

as $\Delta\phi(n)$ serving as the differential value from which the offset component has been eliminated.

26. The jitter measuring method according to claim 25, wherein

the step of integrating the differential value from which the offset component has been eliminated

carries out a following integration

$U(n)=\Sigma\Delta\phi(i)$ (Where, the symbol Σ denotes the sum total of i=0,1,2, ..., n, and here, provided that U(n) is theoretically expanded, it is made to be

$U(n)=[\phi(0)-\phi(-1)]+[\phi(1)-\phi(0)]+$
$[\phi(2)-\phi(1)]+.........+[\phi(n)-\phi(n-1)]$

$=\phi(n)-\phi(n-1)$

with respect to $\Delta\phi(n)$ serving as the differential value which is output by the step of eliminating the offset component, and from which the offset component has been eliminated,

and here, given that $\phi(-1)=0$, an integrated result U(n) is to express a jitter component $\phi(n)$ of the signal to be measured, and

outputs the integrated result U(n) as the jitter component $\phi(n)$ of the signal to be measured.